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ENVIRONMENTAL DATA MAPPING PROGRAM - EDMAP

By

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ADMINISTRATIVE REPORT LJ-87-25

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INTRODUCTION

EDMAP is a self contained program for making contour plots of two-dimensional scalar fields, defined by randomly distributed data. It can also make digital plots, showing the values of the field at grid points or at the actual locations of the data points. It can display wind fields by plotting arrows at grid points. There is also a limited capability for combining or modifying gridfields created during separate runs and stored in disk files.

The process of making a plot includes one or more of the following steps:

1. Read data values from user's source file.
2. Analyze the data to define a gridfield at the nodes, or grid points, of a rectangular grid.
3. Modify or combine gridfields created in the current run and/or in preceding runs.
4. Track contours through the gridfield.
5. Organize the plot parameters necessary to create a plot and issue calls to a specific device driver or plot package.

A provision for saving and retrieving the output of each step allows a job to be carried out in a single computer run or in a succession of runs. The outputs of steps 1 and 4 are saved automatically in data files and plot files, respectively. The outputs of steps 2 and 3 are saved in grid files, at the user's option. All three file types are created as permanent files and remain on the user's disk until removed.

The present version of EDMAP has been modified in an attempt to simplify the selection and submission of parameters. The parameters must be loaded in a command file, in a prescribed sequence, prior to execution. An ancillary program, EDMAPCMD, is available to assist in the creation of command files. It prompts the user for the parameters needed and assembles them in proper order. Command files created by EDMAPCMD are ASCII text files and can be modified as desired with any editor.

PROGRAM PARAMETERS

EDMAP uses three kinds of parameters: option parameters, specification parameters, and filename parameters. They must be submitted in that order (in the command file) for each run, preceded by a TITLE (any string of 30 characters or less). The number symbol <#> is used as a delimiter, and must be inserted after the TITLE and after each group of parameters (options, specifications, filenames).

Each set of parameters initiates one run of the program. A command file may contain any number of such sets, allowing for multiple runs in a single job. The last set of parameters must be followed by the command <QUIT>.

OPTION PARAMETERS

Option parameters consist of commands and command qualifiers, separated by slashes </>. Some commands require additional information, enclosed in parentheses. Commands must be separated by one or more spaces and entered in the order that they are to be carried out.

The general syntax for option parameters is:

COMMAND/Qualifier(s)(additional info.)

The kind of additional information required depends on the particular command with which it is submitted. When included, it will always consist of a sequence of numeric or alphabetic fields, separated by either spaces or commas. A description of each command option is given below.

LOADSORC/Qualifier(data selection info.)

Initiates input from user's source file and converts the X and Y coordinates of the source data to I and J coordinates of a grid defined according to the specification parameters. The converted coordinates, along with their respective data values are stored in a data file identified as <IJVAL> in the program. The actual file will remain on disk until deleted by the user. The qualifier must be entered as one of four keywords, described below. Each qualifier option designates a particular source file format and must be submitted with specific information about that format.

/XYDAT(nflds,xloc,yloc,vloc,HDRS)

The actual name of the source file must be equated to <XYDAT> in a filename parameter. The elements inside the

parentheses relate to the record format: nflds is the number of fields in each record, xloc is the sequence number of the field containing the X coordinate, yloc is that for the Y coordinate and vloc is that for the variable to be extracted. The last field, <HDRS>, must be entered as shown, if the data contains header records. Otherwise, it should be omitted. <HDRS> will cause EDMAP to interpret the first six characters of the first record in the file as a header designator, and to ignore every record in the file that starts with those characters.

Free field format is the default mode for records in XYDAT files. In this mode, data fields in a record must be separated by one or more blank characters, and each field must contain at least one nonblank character. Column alignment of fields from record to record is not required.

EDMAP can accept <XYDAT> files with fixed record formats if the specification parameter <FMT=1> is entered and <LOADSORC> is submitted with extensions, as follows:

LOADSORC/XYDAT(nflds,xloc,yloc,vloc,FMT)/SETCNT(field_
length_list)

where the second qualifier,</SETCNT>, is the same as that described for <TRACKCNTRS>, and cannot be submitted with both commands in the same run. The data fields are assumed to be right justified. The field_length_list must contain the number of characters in each field of a record, including leading blanks, if any. The keyword <FMT> is required in the first set of parentheses, but does not preclude the inclusion of <HDRS>. The field_length_list can extend to more than one line in the command file.

/OCNDAT(vrbl,ycor,xcor,skip)

As with <XYDAT>, the actual name of the source file must be equated to <OCNDAT> in a filename parameter. <OCNDAT> is the CalCOFI oceanographic data file assembled at SWFC. The fields inside the parentheses identify the variable and the coordinates to be selected. Valid entries for vrbl are: <TMP>, <SAL>, <OXY>, <SIGT>, <OSAT>, <DYNA> and <DEPTH>. Valid entries for ycor are <TMP>, <SAL>, <OXY>, <SIGT>, <DEPTH>, <DISTN> or <DISTP>. Valid entries for xcor are: <TMP>, <SAL>, <OXY>, <SIGT>, <TIME>, <DISTN> or <DISTP>. <OCNDAT> files contain one or more data sets, each of which begins with a header record. When a file contains multiple data sets, each usually represents one cruise. An integer designating the sequence number of the data set to be selected must be entered for the fourth field, skip. If the file contains just one data set, the value <1> should be entered for skip. Only one data set can be processed in a single run.

/MWXOB(vrbl,yrmo,day_from<->day_to)

Ship's synoptic surface weather observations received from Fleet Numerical Oceanographic Center are stored at SWFC in the <MWXOB> format. The fields inside the parentheses specify data to be selected. Valid entries for vrbl are: <SST>, <WIND>, <WSPD>, <PRES>, <CLDS>, <AIR>, <DEW>, <EVAP>, <SWDIR> and <SWHGT>. A year-month code is entered for yrmo, and day_from, dash, day_to designates the period to be selected. For example, 8707 01-31 would select July 1-31, 1987.

/MARDAT(vrbl).

This represents a file of monthly mean sea surface temperature by one degree squares for the Pacific Ocean. The only valid entry for vrbl is <SST>.

MOREDATA

Provides a means for accumulating input data from more than one source file. It is relevant only when submitted with <LOADSORC> and terminates the run for which it is entered. A second set of run parameters must be present in the command file and must also include a <LOADSORC> command, designating a different source data file. Each new set of source data is accumulated in the data file equated to <IJVAL>.

ANALYZE/Qualifier

Loads the data stored in <IJVAL> and fits the values to the grid points, or nodes, of a two-dimensional grid, represented by an array in memory. The process has two phases: (1) direct assignment of data values to grid points, and (2) interpolation of values for grid points not affected by direct assignment. Direct assignment applies only to grid points within one mesh length of each data value. The interpolation in phase 2 can be carried out across spans of varying length, depending on the value submitted for the specification parameter <ANL>. This command has four qualifiers, all of which are optional. Multiple qualifiers must be separated by slashes.

/CENTER

Forces the assignment of each data value to the nearest grid point. Otherwise, each data value makes a weighted contribution to each of the four surrounding grid points.

/SETNUL

Assigns the value submitted as the specification parameter <NUL> to grid points not assigned values in either phase 1 or 2, above. It is used to suppress contours, on contour

plots, in areas where the gridfield is not defined by data.

/GUESSFLD

Provides a way to examine and reject values from the data file <IJVAL> which fail to satisfy selection criteria. When this qualifier is submitted, each element of the gridfield in memory is initialized, either with the constant value specified by the parameter <GSS>, or from a grid file loaded prior to analysis. Each data value from <IJVAL> is compared to the value of the initialized gridfield, interpolated to the location of the data point. If the absolute value of the difference exceeds the value of the parameter <REJ>, the data value is rejected.

/SKIPFIT

Suppresses input of data from file <IJVAL> and phase 1 of the analysis process. It must be preceded by a <LOADFx>, (x=1..4) command (described below) initializing the gridfield in memory from a grid file created in a previous run. It can be used to complete the analysis (phase 2) of a gridfield which had been saved in a previous run after completion of phase 1 (See description of the specification parameter <ANL>).

SMOOTH

Invokes a two-dimensional smoothing function which modifies the gridfield in memory at each grid point. A choice of smoothing options is provided by different combinations of two 9-point operators which are selected by the specification parameter <SMH>.

SAVEF1,SAVEF2,SAVEF3,SAVEF4

These four commands each create a disk file which contains the contents of the gridfield in memory at the time the command was activated. The corresponding file identifiers, internal to EDMAP, are: <FIELD1>, <FIELD2>, <FIELD3> and <FIELD4>. The provision of four different grid file identifiers gives EDMAP flexibility to carry out operations which modify or combine gridfields. Reference to the flow chart (Figure 1) will assist in the placement of <SAVEFx> and <LOADFx> (x=1..4) commands to insure the presence in memory of the right gridfield at the right time.

LOADF1,LOADF2,LOADF3,LOADF4

These four commands are used to retrieve gridfields previously saved on disk with one of the <SAVEFx> (x=1..4) commands described above. The retrieved file replaces or may be combined with, the gridfield in memory. The same file may be retrieved more than once in the same run. For example, a field

of mean values could be loaded before analysis of a data field, as a reference field for editing source data, and again after analysis to be subtracted from the data field to create an anomaly field. Reference to the flow chart (Figure 1) will assist in the placement of <LOADFx> and <SAVEFx> (x=1..4) commands in the command file.

EDITFLD/Qualifier

This command invokes a call, during execution, to an external subroutine which can perform special modifications to a gridfield. The name of the external subroutine must be ADJUSTFLD, and it must reside in an object file linked to EDMAP prior to execution. ADJUSTFLD can contain one or more special purpose routines, which can be activated by submitting an appropriate identifier for the qualifier option. The qualifier can be any string of 36 characters, or less, and will be passed to ADJUSTFLD as a string parameter. Information needed to create an executable image of EDMAP containing a customized version of ADJUSTFLD is given in a later section.

RECTIFY(additional info)

This command can be used to rectify common boundaries of gridfields which were analyzed separately, and are meant to be combined in a single contour plot. Contours in adjacent gridfields, approaching a common boundary from opposite sides may not meet, particularly if smoothing was performed on either gridfield or they were defined with different grid lengths. <RECTIFY> modifies the gridfield in memory, at run time, to make it compatible with up to four reference gridfields, created in previous runs and saved in grid files. The names of the reference grid files must be included in the command as additional information. Each grid file name must be followed by a designator, <NORTH>, <EAST>, <SOUTH> or <WEST>, indicating that the reference grid is above, to the right of, below or to the left of the grid in memory. For example:

RECTIFY(GRIDFIL1.DAT,EAST,GRIDFIL2.DAT,SOUTH)

would cause grid point values along the right boundary of the gridfield in memory to be modified by data in GRIDFIL1.DAT and those along the lower boundary to be modified by data in GRIDFIL2.DAT. The grid intervals of reference gridfields must be less than or equal to the grid interval of the gridfield in memory.

SUBTRACT

This command is used with, and must be preceded by a <LOADFx> (x=1..4) command. It causes an associated grid file, identified internally as <FIELDx> (x=1..4), to be loaded and

subtracted point by point from the gridfield in memory. The result of the subtraction replaces the gridfield in memory.

ADDFLD

Combines a previously saved gridfield with the gridfield in memory. As with <SUBTRACT>, it must be preceded by a retrieve command, <LOADFx> (x=1..4), to access a grid file on disk associated with one of the internal filenames, <FIELDx>, (x=1..4). The grid point values from the grid file are added to those in the gridfield in memory, point by point. The result replaces the gridfield in memory. <ADDFLD> and <SUBTRACT> cannot be entered in the same run.

PRINTFLD

Creates a printer file of the gridfield in memory, and its associated count field. The resulting file is an ASCII text file, with a maximum line length of 72 characters. It contains row and column labels in the user's (X,Y) coordinates. The internal name of the output file is <LPRINT>.

TRACKCNTRS/Qualifier(additional info.)

This command initiates the contour tracking routine on the gridfield in memory. The gridfield is scanned for selected contours by examining every pair of adjacent grid points. When a contour segment is encountered, the scanning is suspended while the contour is tracked and its coordinates recorded. Contour selection may be made with the specification parameters <COG>, <CIN> and <CTX>, or with a contour list specified as (additional info.) in the command line following the qualifier option, <SETCNT> (see below). The degree of smoothness of contours is affected by the value of the specification parameter <SQD>. If this value is greater than 1, it is squared to define a subsquare matrix for each unit grid area through which a contour is tracked. Coordinates are computed by curvilinear interpolation at each point where the contour intersects a subsquare boundary. The contour coordinates are organized by contour segments and stored in a plot file equated to the identifier <PLTFIL>. These segments will be retrieved with the command <PLOTCNTRS> and reorganized as array parameters to be passed to CALLPSUB, a procedure that constructs plot calls for specific plot drivers.

Two qualifier options are available for <TRACKCNTRS>.

/FIXDBL

This qualifier imposes a constraint on the curvilinear interpolation, to suppress spurious features which can result

when sharp differences in gradients occur between adjacent pairs of grid points.

/SETCNT(contour list)

This option specifies that contour selection is to be made solely from the contour list inside the parentheses. The elements in the list should be unscaled values separated either by spaces or commas. The list may occupy more than one line.

PLOTCNTRS/Qualifier

One of six commands which lead to the creation of a plot. All plot commands invoke a primary plot module which processes plot specification parameters and passes them on to a secondary module, CALLPSUB, referred to earlier. The latter is tailored to specific plotter software (see APPENDIX B).

The implementation of EDMAP on the VAX 11-780 is linked to the Zeta plot subroutine library. The output produced with this package is a disk file named PLOT.ZPL created for the 11-inch Zeta plotter. The qualifier option can be used to change the default filename and windowing specification for Zeta plots. The new filename must be entered as four letters followed by two digits, either 11 or 34. For example: <PLOTCNTRS/name34> would change the disk file to name.ZPL and call for the 34-inch plotter.

In the implementation of EDMAP for IBM PC compatibles, the secondary plot module creates an ASCII text file of plot calls. This file can be read by programs written to drive specific plotters connected as peripherals to the PC.

<PLOTCNTRS> reads contour coordinates from a disk file, equated to the internal name <PLTFIL>), created by <TRACKCNTRS>. Contour labels will be inserted in selected contours at staggered locations, unless the specification parameter <CTL> is zero. Tic marks and labels will be plotted along the plot border in accordance with the specification parameters <XTC>, <YTC>, <XLB>, <YLB>, <XLP>, <YLP>, <XLD> and <YLD>. The string submitted as the TITLE for the current run will be plotted below the lower left border. If a title is not wanted in the plot, the TITLE parameter should be entered as one or more blanks in the command file. The height of the TITLE and of all contour and axis labels is specified by <HGT>. The dimensions of the plot are specified by <MFX> and <MFY>.

XYDATAPLT

Causes data values from the data file <IJVAL>, created by <LOADSORC>, to be plotted at their actual coordinates. Alternately, the data values can be replaced by a symbol,

depending on the value submitted for the specification parameter <SYM>. If <SYM> is zero, the data values will be plotted. If it is greater than zero, the value will be interpreted as a selection code. On the VAX 11-780, <SYM> selects a symbol from the ZETA symbol table. In the PC implementation, it is interpreted as an ASCII character code. <XYDATAPLT> can be used together with <PLOTCNTRS>, <VECTORPLT>, <CONCATPLT> or <OVERLAYPLT>.

DIGITPLT

Causes the grid values from a grid file, equated to the file identifier <GRDFIL>, to be plotted at grid point locations. The number of decimal places to be plotted for each value is determined by the parameter <DPL>. If <DPL> is zero, the decimal point will be suppressed. <DIGITPLT> can be used together with <PLOTCNTRS>, <CONCATPLT> or <OVERLAYPLT>.

VECTORPLT

Produces a plot of arrows and numbers representing directions and magnitudes of wind vectors at grid points, from values stored in a grid file equated to the internal name <GRDFIL>. Wind data can be designated in the <LOADSORC> command line under either of two source file options, </XYDAT> and </MWXOB>. When this happens, the data file equated to <IJVAL> is formatted in a special way and identified as vector data. Analysis of wind data to the gridfield, in <ANALYZE>, is also performed in a special way, and vector gridfields cannot be processed by <PRINTFLD> to create printer files.

The specification parameter <VEC> provides control over the length of the arrows and determines whether the wind magnitude will be plotted. By default, the vector mean magnitude is plotted above the arithmetic mean at each grid point location. <VECTORPLT> can be used together with <PLOTCNTRS>, <XYDATAPLT>, <CONCATPLT> or <OVERLAYPLT>.

OVERLAYPLT

This command provides a capability to superimpose special features on a plot, such as coastlines (for geographical plots), nonstandard labels, scales, titles and other text. The overlay plot data must be stored in a disk file equated to the internal filename <CSTFIL> at run time. Overlay plot files are created with a program named MAKOVRLA, which is described in a subsequent section. <OVERLAYPLT> can be used together with any of the other plot commands, except <CONCATPLT>.

CONCATPLT/Qualifier

Provides a capability to concatenate plot files. Each of

the other plot commands deals with a specific kind of plot and each is associated with a unique internal file identifier, with the exception of <GRDFIL>, which is referenced by both <DIGITPLT> and <VECTORPLT>. <CONCATPLT> can be used to concatenate plot data from up to 999 plot files on a single plot. However, they all must be the same type of plot file, that is, <PLTFIL> or <GRDFIL> or <IJVAL>. Plot files of type <CSTFIL> (used with OVERLAYPLT) cannot be concatenated.

The qualifier option is mandatory and designates the plot file type. It must be selected from the following list:

</DATPLT>, </CTRPLT>, </GRDPLT>, </VECPLT>.

File switching, during concatenation, is keyed to the filename extension, which must be a three-digit string. The filename extensions must form a consecutive sequence of integers. The filename whose extension represents the smallest number in the sequence must be equated to the primary plot file identifier in a filename parameter. The one with the largest extension number must be equated to <CONCAT>. The plot files to be concatenated must all have the same name, except for the extension.

For example, suppose a series of EDMAP runs has created five plot files of contour coordinates representing contiguous segments of a geographical region. If the filenames are AREA.001, AREA.002, AREA.003, AREA.004 and AREA.005, then the requisite filename parameters would be: PLTFIL=AREA.001 and CONCAT=AREA.005. The program would plot the data in AREA.001 first, and then proceed with the other four, starting with AREA.002.

TIMEPLT/Qualifier(additional info.)

Provides a special mode of handling alternative units and labeling options for the X coordinate of a plot when the X coordinate is <TIME>. It is applicable only when the source file type is <OCNDAT>. The qualifier option is required and must be entered as one of three keywords:

</YRMO>, </MNTH> or </DAYS>.

The selection must agree with the actual units of X coordinate values in the source file. When the qualifier option is entered as </MNTH> or </DAYS>, the plot is presumed to depict an annual cycle with a range of 1..12 for </MNTH> and 1..365 for </DAYS>. The actual values of the coordinates in the source file need not be restricted to these ranges, however, and the specification parameters <XZO> and <XMX> may be set to allow any number of repetitions of the annual cycle.

When the qualifier option is </MNTH>, the parameter <XGD> should be entered with a value of 1. When the option is </DAYS>, the value submitted for <XGD> should be a simple fraction, or multiple, of 30.42. The X-coordinates of data from the source data will automatically be converted to Mnth with the formula:

Mnth=(Xcoord+15.21)/30.42.

The (additional info.) portion of the command line specifies whether the X axis labels will be plotted as letters or digits. The valid entries are <LTRS> and <DGTS>. If <LTRS>) is submitted, X axis labels will be selected from the month abbreviations: JAN, FEB, MAR,..,DEC. In addition, when the qualifier option is </YRMO>, the appropriate year will be plotted below each JUL. If <DGTS> is submitted as (Additional info.), and the qualifier option is </YRMO>, the appropriate year-month code will be plotted as X axis labels. Otherwise, two-digit codes will be selected from the sequence 01,02,..,12.

SPECIFICATION PARAMETERS

Specification parameters provide information for defining the gridfield and for carrying out certain command functions. Each parameter entered into the command file must be preceded by a specification keyword and an equal sign, for example: XZO=10. Specifications must be separated by one or more spaces.

There are four groups of specification parameters, each of which affects one or more of the primary functions associated with command options. They are:

1. Parameters for defining a gridfield.
2. Parameters for analyzing source data to a gridfield.
3. Parameters for selecting and tracking contours.
4. Parameters for making a plot.

The parameters in the first group must be entered for every run, because they specify the dimensions of the gridfield and the relation between the (I,J) coordinates of the gridfield and the (X,Y) coordinates of the data field. Other specification parameters are set to default values at the beginning of each run. The default values are then replaced by the user's entries for that run. The particular specification parameters relevant to each option command were pointed out in the preceding section.

1. Parameters for defining the gridfield.

XZO,YZO,XMX,YMX

These four parameters specify the left, lower, right and upper boundaries, respectively, of the gridfield. They must be entered in units of the X and Y coordinates of the data field. If the data field is geographical (with coordinates of latitude and longitude), one of the letters N, S, E or W must be appended to each parameter value, as appropriate.

XGD,YGD

These parameters specify the interval between grid points (mesh length) along the X and Y coordinates, respectively. They must be entered in the same units as the boundary specifications. EDMAP designates the (I,J) coordinates of the grid at the lower left corner (defined by <XZO> and <YZO>) as the grid origin (1,1) and the (I,J) coordinates at the upper right corner (defined by <XMX> and <YMX>) as (IMX,JMX). The values of IMX and JMX, therefore, define the grid dimensions; they are computed from the grid specifications as follows:

```
IMX = TRUNC((XMX-XZO)/XGD +1.5)
JMX = TRUNC((YMX-YZO)/YGD +1.5)
```

where TRUNC means the evaluated expression is truncated to an integer.

PJC

Identifies the type of coordinates as geographical, oceanographic or other. The range of valid parameters is 1 to 5, as defined below:

1. Geographical projection (Mercator).
2. Geographical projection (Lambert's Equal Area).
3. Geographical coordinates (no projection).
4. Oceanographic coordinates with depth as the Y coordinate.
5. Any other linear rectangular coordinates.

MPR

Specifies a reference longitude for geographical coordinates when <PJC><=3. The sum of the distances from <MPR> to <XZO> and <XMX> must not exceed 180 deg. The value entered should be followed by W or E for west longitude or east longitude, respectively.

2. Parameters for fitting data values to a grid.

ANL

Specifies the scope of interpolation for grid points which were not assigned values directly from source data. The interpolation for such grid points is carried out after all the values in the data file have been processed. The method is described in a later section. The value submitted for <ANL> is interpreted as the maximum number of grid intervals across which interpolation can be performed in the attempt to assign values to undefined grid points. If <ANL> is submitted as an integer, it applies to both the I (horizontal) and J (vertical) directions. If it is submitted as mixed number, the integer part will apply to the I direction and the fractional part, multiplied by 10, will apply to the J direction, except if the fractional part is <.1> it will converted to 10.

Certain values of <ANL> invoke special actions, as follows: if <ANL>=0 the analysis procedure will be bypassed and the command option <ANALYZE>, if submitted, will be ignored; if <ANL>=1, the analysis procedure will be terminated after phase 1, the direct assignment of the data values to gridpoints. Otherwise, the value submitted should be in the range 2..10. The search area for interpolation will be approximately proportional to the parameter value squared. The default value of <ANL> is 1.

SCL

Specifies the precision to be maintained in fitting the source data to the gridfield. It should be entered as the number of decimal places to be preserved in computations involving gridpoint values, which are processed as 32-bit integers. <SCL> will be interpreted as a power of ten for scaling the source data.

NUL

Specifies a value to be assigned to grid points which were not defined during the analysis procedure, either by direct assignment of data values or by interpolation. This action is invoked by the qualifier options </SETNUL> when submitted with <ANALYZE>. The <NUL> value is recognized by <PRINTFLD>, and suppresses printing of values at undefined gridpoints. It also suppresses contour tracking through undefined portions of a gridfield by <TRACKCNTRS>. The value submitted for <NUL> should be outside the range of valid data values.

GSS

Specifies a constant value to initialize the gridfield in preparation for editing the data values. Initialization is invoked by the qualifier option </GUESSFLD> when it is submitted with <ANALYZE>. It provides a reference field for the editing process which takes place during analysis. Initialization can also be accomplished by submitting a load command, <LOADFx> (x=1..4), prior to the <ANALYZE/GUESSFLD> command, when an appropriate grid file is available from a previous run. When a gridfield is initialized with a <LOADFx> command, the parameter <GSS> is ignored.

REJ

Specifies a window for accepting or rejecting data values during the analysis process when editing has been invoked by the qualifier option </GUESSFLD>, submitted with <ANALYZE>. It requires prior initialization of the gridfield, as described for <GSS> above. The editing is performed by comparing each data value with the value of the initialized gridfield (reference field) interpolated to the coordinates of the data value. If the absolute value of the difference exceeds the value of <REJ>, the data value will be rejected. If <REJ>=0 (default value) no editing will be performed.

SMH

Specifies a selection code for smoothing the gridfield when the command option <SMOOTH> is submitted. The smoothing is applied point by point to the gridfield in memory, and the result replaces the gridfield in memory. Smoothing is employed to reduce or eliminate small scale irregularities in contoured fields while retaining the essence of large scale features.

EDMAP contains three nine-point (two dimensional) smoothing operators. Each is equivalent to a three point operator applied in a direction parallel to the X axis first, then to the Y axis. The weights for the primary operator are (1 2 1). The effective weights that would result from repeated applications of this operator can be seen in a table of binomial coefficients. The original (unsmoothed) value at a grid point would contribute 25% to the smoothed value at that point, after one pass, and just over 14% after two passes. A secondary operator, with weights of (-1 6 -1), is provided to restore weight to the original value. The contribution of the latter to a smoothed grid point value after one pass of each of these operators (selected with <SMH>=2) would be just over 39%.

A third operator, with weights of (1 8 1), was designed for fields of discrete (instead of continuously varying) elements. Such fields may require some smoothing to avoid overloading

EDMAP's tracking capacity with too many contour segments, but would be oversmoothed by the first two operators. The contribution of an original grid point value to a smoothed value after one pass of the third operator would be 64%.

The results obtained with different values of <SMH> are described below.

0 No smoothing occurs; the <SMOOTH> command is ignored.

1 The primary smoothing operator is applied once.

2 The primary smoothing is applied followed by the secondary operator; equivalent to applying a single 25-point operator.

3 The primary smoothing operator is applied twice; equivalent to applying a single 25-point operator.

10 The third smoothing operator is applied once.

Light smoothing results when <SMH>=1. The actions described for 2 or 3 can be repeated by adding multiples of 3 to either code. For example, entering 8 for <SMH> would cause the smoothing described for code 2 to be applied three times.

3. Parameters for tracking contours.

COG

Specifies the lowest valued contour that will be selected for the tracking process. The value entered for <COG> should, therefore, be small enough to ensure that all desired contours in a gridfield will be selected. There is no corresponding upper limit. The default value of <COG> is 0.

CIN

Specifies a fixed interval for contour selection, provided that the value of <CTX> equals 0 (see below) and that contour selection is not superseded by the qualifier option </SETCNT>. When CIN is the determining parameter, contours will be selected from the following sequence:

COG, COG+CIN, COG+2*CIN, COG+3*CIN,...etc.

The default value for CIN=1.

CTX

Specifies a base for selecting exponentially varying contours. When the value submitted for <CTX> is greater than

1 and contour selection is not superseded by the qualifier option </SETCNT>, contours will be selected from the following sequence:

COG, COG+1, COG+CTX, COG+CTX^2, COG+CTX^3,...etc.,

where <^> denotes exponentiation. When <CTX> is used to determine contour intervals, <CIN> is ignored and <COG> should be greater than or equal to zero.

SQD

Specifies a subsquare division factor which controls the resolution with which contours are tracked through unit grid squares. When a grid square is entered, in the tracking process, it is divided into a number of subsquares determined by the value of <SQD> squared. Coordinates will be computed for a contour at points of intersection with subsquare boundaries, by means of a curvilinear interpolation procedure. Values submitted for <SQD> should be in the range 1..10. The larger values result in smoother contours and increased CPU time. The default value of <SQD> is 1.

4. Parameters for making the plot.

ORG

Sets the plot origin on the Y axis. The plot origin is the point corresponding to the grid coordinates (I,J)=(0,0). The value submitted for <ORG> specifies an upward displacement, in inches, of the plot origin relative to the lower left pen position on the plotter. The default value is 1.0. The lower left corner of the plot border is at the grid origin, where the plot coordinates are (I,J)=(1,1). Consequently, the usable margin below the plot border is equal to <ORG> plus one mesh length along J.

SPB

Suppresses the plot border when entered with a value of 1. Otherwise, the border will be plotted. When <SPB>=1, all plot parameters affecting tic marks or labels along the plot border will be ignored. The default value is 0.

MFX,MFY

These parameters determine the size of the plot, and must be entered as inches per unit of X and Y, respectively, where X and Y are the coordinates of the user's source data. The plot width is determined by multiplying the range of X by <MFX>. The plot height is determined by multiplying the range of Y by <MFY>, except when the projection code parameter, <PJC>, has a

value of 1 or 2. In those cases, the plot height is a function of plot width and <MFY> is ignored. The values of <MFX> and <MFY> for any desired plot width and height can be computed with the following formulas.

<MFX>=Plot_width/ABS(<XMX>-<XZO>)
<MFY>=Plot_height/ABS(<YMX>-<YZO>).

HGT

Specifies the height (in inches) of axis labels, contour labels, and characters in the TITLE parameter. The latter will be plotted below the lower left plot border. The default value of <HGT> is 0.16.

XTC,YTC

Specify how tic marks will be plotted along the plot border Tic marks can be plotted only at grid points, that is, at intervals specified by the parameters <XGD> and <YGD>. The locations of tic marks and labels along both X and Y axes are determined with reference to the grid origin, where (I,J)=(1,1). If <XTC>=0 or <YTC>=0 (default values), the corresponding tic marks will be suppressed. Otherwise, tic marks will be plotted at every <XTC>th grid point along the X axis, and at every <YTC>th grid point along the Y axis. When <XTC> or <YTC> is greater than 1, the placement of the first tic mark will be determined by <XLP> or <YLP>, as appropriate, in such a way as to avoid offsets between tic marks and labels.

XLB,YLB

Specify the spacing between labels plotted along the X and Y axes. The placement of the first label relative to the grid origin, where (J,I)=(1,1), will be determined by the value of <XLP> or <YLP>. The number of decimal places in axis labels will be determined by the parameters <XLD> and <YLD>. Values entered for <XLB> and <YLB> will be interpreted as the number of grid intervals (not intervals between tic marks) between labels. If the value of either parameter is 0 (default value), the corresponding labels will not be plotted.

XLP,YLP

Specify starting points for plotting labels along the X and Y axes. The parameter values will be interpreted as the number of grid intervals to skip before plotting the first label. For example, if <XLP>=2, the first label on the X axis would be plotted at the third grid point from the plot origin. Subsequent labels would be plotted at intervals specified by <XLB>.

XLD,YLD

Specify the number of digits to be plotted to the right of of the decimal point in X and Y axis labels. If either parameter is entered as zero, the corresponding decimal points will not be plotted.

DPL

Specifies the number of decimal digits to be plotted to the right of the decimal point for grid or data values when either <DIGITPLT> or <XYDATAPLT> is submitted. In the latter case, <DPL> would be ignored if the value of <SYM> was greater than or equal to one. The default value of <DPL> is 0.

CTL

Controls the plotting of contour labels. If the value of <CTL>=0 (default value), no labels will be plotted. If <CTL>=1, every contour will be labeled; otherwise every <CTL>th contour will be labeled.

The number of decimal places in contour labels is automatically determined from the current value of <CTL>, and from values of <COG> and <CIN> that were current in the run when the plot file was created. The default value for <CTL> is 0.

SYM

Specifies whether data values or special symbols are to be plotted at the locations of source data points, when the command option <XYDATAPLT> is invoked. If the parameter value is 0 (default value), then the data values will be plotted as decimal numbers with the number of decimal places specified by the parameter <DPL> as described above. Otherwise, the value for <SYM> may be entered as a mixed number, in which case the integer part will be used to select a symbol from the symbol table associated with a particular plot package or from the ASCII character set. The fractional part will be multiplied by the value of the parameter <HGT> to determine the height of the plotted symbol. If the fractional part is zero, it will be interpreted as 1 for this purpose.

At run time, the current value of <SYM> is stored in the header record of the data file equated to <IJVAL> when that file is created by the command <LOADSORC>. It is recovered when <IJVAL> is opened by <XYDATAPLT> and used as described above. This provides a means for assigning different symbols for different sets of data on the same plot.

VEC

Specifies whether the magnitudes of wind vectors will plotted or suppressed when the command option <VECTORPLT> is invoked. It also controls the lengths of arrows depicting the wind directions. The parameter value may be entered as a mixed number. The integer part must be either 1 (to plot the magnitudes) or 0 (to suppress them). If <VEC>=1 (or greater), the mean vector magnitude will be plotted above the arithmetic mean at each grid point. The ratio of the vector mean to the arithmetic mean is a measure of the steadiness of the wind at grid points, when the number of data values represented is more than one. The magnitudes will be plotted as rounded integers.

The fractional part of the parameter value will be multiplied by the mesh length of the grid along the X axis to determine the length (in inches) of the arrow shafts. If the fractional part is zero or missing, it will be interpreted as one for this purpose. The mesh length is determined by the product of the specification parameters <MFX> and <XGD>.

XPV,YPV,ROT

These three parameters provide for rotation of the (I,J) coordinates with respect to the (X,Y) coordinates when a plot is created. This capability has particular application in mapping data on the CalCOFI grid. It allows the use of station and line numbers as X and Y coordinates for analyzing CalCOFI data to a rectangular gridfield and facilitates conversion to latitude and longitude when making a plot.

The values submitted for <XPV> and <YPV> will specify the (X,Y) coordinates of the pivot point. The value of <ROT> specifies the amount of rotation in degrees (positive counter-clockwise). The geographical orientation of the CalCOFI grid represents a counterclockwise rotation of 30 degrees from a north-south direction, around a pivot point about 44 nautical miles off Point Conception, on the California coast. The rotation parameters applicable to CalCOFI grid rotation are:

<XPV>=121.15W
<YPV>=34.15N
<ROT>=30.0

These values should be used only for the CalCOFI grid, since they result in a transformation of coordinates as well as axis rotation. However, the rotation parameters can be used in plotting any gridfield by submitting a nonzero value for <ROT>, and appropriate values for the pivot point parameters, <XPV> and <YPV>.

FILENAME PARAMETERS

Filename parameters equate the names of actual disk files. read or created by the program, to internal file identifiers. EDMAP uses four kinds of external files: source files, data files, grid files and plot files. Source files contain user's data, and are for input only. Data files are created when source files are read and contain a subset of the data values along with their respective coordinates. Grid files contain the array of grid point values that define a gridfield. They can be created by option parameters submitted by the user. Plot files are created by the contour tracking routine and contain contour coordinates of selected contours.

Filename parameters provide the user a means of identifying his source files to be processed and of controlling the naming of all other files created by the program. Filename parameters equate file identifiers in the program to actual filenames on disk. The syntax is:

FILID=Filename

where FILID is one of fourteen keywords (listed below) and Filename is the actual filename. Each of the fourteen keywords is associated with an internal file identifier and, with one exception, falls in one of the four file type categories referred to earlier.

	File Identifier (keyword)	File Type
1.	FIELD1.....	Grid file
2.	FIELD2.....	Grid file
3.	FIELD3.....	Grid file
4.	FIELD4.....	Grid file
5.	IJVAL.....	Data file
6.	PLTFIL.....	Plot file
7.	GRDFIL.....	Grid file
8.	CSTFIL.....	Plot file
9.	CONCAT.....	Plot file
10.	XYDAT.....	Source file
11.	MWXOB.....	Source file
12.	MARDAT.....	Source file
13.	OCNDAT.....	Source file
14.	LPRINT.....	Printer file

The last file in the list is created by the option <PRINTFLD>, and contains the same grid point values that are stored in grid files. The printer file, however, is organized in a report format and includes column and row labels. A printer file also contains the count field, which represents the number of source data values used to compute each grid value.

GRIDFIELD MODIFICATION WITH ADJUSTFLD

The command options provide a few standard ways to modify or combine gridfields created by EDMAP. For added flexibility, the option <EDITFLD> can be used to perform any desired modification of the gridfield at run time, with customized routines contained in a subroutine named ADJUSTFLD. This subroutine must reside in an object file linked to EDMAP at run time. The parameters must be compatible with, and in the same sequence as those described below.

```
SUBROUTINE ADJUSTFLD(SUBNAM,GRID,RS,IMX,JMX,NUL)
```

SUBNAM

This is a string variable of 36 characters. It will be passed to ADJUSTFLD as the qualifier submitted with the <EDITFLD> command. Its inclusion as a parameter provides a means to select one of several routines that might be included in ADJUSTFLD, thereby avoiding the need to relink EDMAP with different files each time a different routine is needed. If the <EDITFLD> qualifier has embedded spaces, they will be replaced by the underscore character <_> in SUBNAM.

GRID

This is the two dimensional array representing the gridfield in memory. The size of the gridfield is JMX elements in the Y direction (rows), by IMX elements in the X direction (columns). However, the actual size of GRID is JMX by RS elements, where RS is computed automatically and is always greater than or equal IMX. This results from compatibility requirements with respect to the record structures used by EDMAP for creating grid files. The value of RS is included in the actual parameter list so that it can be used by ADJUSTFLD to declare the correct array dimensions for GRID.

RS,IMX,JMX

These parameters are integers defining the dimensions of the gridfield and are used to set dimensions for the array parameter, GRID, as explained above. IMX and JMX can be used as control variables for scanning the gridfield.

NUL

This is the null value, computed from the value of the specification parameter <NUL> multiplied by the scale factor (10^SCL). The grid point values in GRID will also be multiplied by the scale factor before GRID is passed to ADJUSTFLD. The inclusion of <NULL> as a parameter allows the subroutine to work around undefined grid points.

CREATING OVERLAY PLOT FILES WITH MAKOVRLA

The command option <OVERLAYPLT>, in conjunction with the filename parameter <CSTFIL>, provide a means of superimposing special titles, captions, labels, scales, and other features (including coastlines) on a plot. The overlay elements must be available at run time in a plot file linked to <CSTFIL> in a filename parameter.

MAKOVRLA and OVRLACMD are a pair of programs designed to facilitate preparation of overlay plot files. MAKOVRLA, like EDMAP, gets its parameters from a command file. The second program, OVRLACMD, is designed to assist the user to create the command file in an interactive mode. Once made, it can be modified as desired with any editor. MAKOVRLA offers nine types of overlay elements, identified by the keywords:

SYMBOL, NUMBER, RECTANGLE, DIAMOND,
POLYGON, BAR, LINES, SCALES and COAST.

Overlay elements are located on a plot with reference to the user's X and Y coordinates and (with the exception of COAST) may be placed anywhere on the plot, inside or outside the plot border. COAST is used only to plot coastlines inside the border.

The file created by <MAKOVRLA> is an EDMAP plot file and must include a header record with identification fields and parameters relating to the gridfield for which the file was created. Consequently, the first set of parameters submitted to MAKOVRLA must contain the information needed for the header record. It must also include a name for the overlay file. Subsequent sets of parameters will contain specifications appropriate to particular kinds of overlay elements. An example of a MAKOVRLA command file will be found at the end of this section.

The identification and header record fields are described below.

FILENAME

This is the name of the overlay plot file. This name can be submitted to EDMAP as a filename parameter equated to <CSTFIL>.

TITLE

Any character string of 30 characters or less.

XZO,YZO,XMX,YMX

These are the grid parameters as defined for EDMAP. They specify the lower left and upper right corners of the gridfield, and must be entered in the sequence shown, as integers or simple decimal numbers (no scientific notation). If the grid coordinates are latitude and longitude, one of the letters N, S, E or W must be appended to each parameter value.

XGD,YGD

These specify the grid interval along the X and Y axes, respectively. They correspond to the EDMAP parameters with the same names.

PJC

This is the projection code, as defined for EDMAP.

MPR

This is the reference longitude as defined for EDMAP. It should be entered as an integer or a real number with either <E> or <W> appended for east or west longitude. <MPR> is relevant only when <PJC> is less than 4.

NUL

This is the null value assigned to undefined grid points in EDMAP. It is relevant to MAKOVRLA only when the COAST element is submitted. The value entered must agree with that submitted to EDMAP in the run that plots the overlay. Coastline segments in overlay plot files are treated the same as contour segments in contour plot files. The null value is used to identify the end of the last segment.

IDP

This is the number of implied decimal places in coastline coordinates (see COAST). When COAST is submitted to MAKOVRLA as an overlay element, it must be accompanied by the name of a file containing coastline coordinates in a prescribed ASCII format. If the coordinates in that file have been scaled by a factor of 10, 100, 1000, etc., then the value of IDP should be entered as 1, 2, 3, etc. Otherwise it should be zero.

The parameters required for each type of overlay element are described below. The parameters must be entered in sets. Each set begins a new line, with an element identifier. There are no restrictions on the number of sets or on the order in which they are entered. In the following descriptions, element identifiers are enclosed by <> symbols to separate them from identifiers that will be replaced by actual numeric or string constants in the command file. Parameters may be separated by spaces or commas.

<SYMBOL>,N,HT,ROT,X,Y,STRING

Plots a character string.

N is the number of characters in the string (including embedded spaces).

HT is height of the characters in inches.

ROT is the rotation of the string, in degrees, around (X,Y).

X,Y are the coordinates of the lower left corner of the first string character.

STRING is the string to be plotted; it must be entered on a separate line.

Example: SYMBOL 13 0.12 0 122.5W 37.7N
SAN FRANCISCO

<NUMBER>,N,HT,ROT (followed by)

N sets of: X,Y,VAL,F.

Specifies a sequence of numbers, where

N is the number of numbers to be plotted.

HT is the height of the numbers in inches.

ROT is the rotation, in degrees, of each number around (X,Y) (positive clockwise).

For each number:

X and Y are the coordinates of the lower left corner of the first digit.

VAL is the number to be plotted.

F is the number of fractional digits to be plotted for VAL.

Example: NUMBER 3 0.16 90
3 1 300 0
6 1 400 0
9 1 500 0

<RECTANGLE>,X,Y,RX,RY

Specifies a rectangle, where

X and Y are the coordinates of the center.

RX is the half-width in inches.

RY is the half-height in inches.

Example: RECTANGLE 5 3 2.0 1.5

<DIAMOND>,X,Y,RX,RY

Specifies a diamond, where

X and Y are the coordinates of the center.

RX is the half-width in inches.

RY is the half-height in inches.

Example: DIAMOND 5 3 2.0 1.5

<POLYGON>,N,X,Y,R

Specifies a polygon with a vertex at the top, where

N is the number of sides in the polygon.

X and Y are the coordinates of the center.

R is the distance from the center to any vertex in inches.

Example: POLYGON 13.3 21.4 5.0

<BAR>,hatch_option,N,SL,SP (followed by)

N sets of: X,Y,DX,DY.

Specifies one or more bars for a bar graph, where

hatch_option must be entered as <HATCH> or <EMPTY> to select hatching or no hatching.

N is the number of bars to be plotted.

SL sets the slant of the hatch lines (range = 0..10). The actual angle of the hatch lines will depend on the grid and plot size parameters.

SP sets the density of the hatching (range = 0..10). Enter 0 when hatch_option is <EMPTY>, 10 for maximum density.

For each bar:

X and Y are the coordinates of the lower left corner.

DX is the width, in X coordinate units.

DY is the height, in Y coordinate units.

```
Example: BAR HATCH 3 4 1
          1 0 0.5 8
          2 0 0.5 13
          3 0 0.5 26
```

<LINES>,N (followed by)

N sets of: X,Y.

Specifies line segments connecting a sequence of points, where

N is the number of points.

X and Y are the coordinates.

```
Example: LINES 5
         13 20
         18 20
         18 25
         13 25
         13 20 (draws a rectangle)
```

<SCALES>,N,DX,DY,X,Y

Specifies a horizontal scale with vertical tic marks. where

N is the number of tic marks.

DX is the spacing between tic marks in X coordinate units.

DY is the height of the 1st, 3rd, 5th,...tic marks, expressed in Y coordinate units; the intermediate ones will have a height of DY/2.

X and Y are the coordinates of one end of the horizontal line depicting the scale. The line will be drawn to the right of (X,Y) if DX is positive, and to the left of (X,Y) if DX is negative. The tic marks will be plotted above the line if DY is positive, and below the line if DY is negative. The length of the line will be equal to: DX*(N-1).

Example: SCALE 6 3 1 10 15

<COAST>,neglon,filename

Specifies that coastline coordinates are to be read from a file designated by filename, and reformatted for the overlay plot file. The geographical quadrants represented by the coordinates must be designated by positive or negative values of latitude and longitude. The standard convention is positive for north latitude and negative for south latitude. There are different conventions for longitude, however, and it is necessary to submit an entry for neglon to designate that negative longitudes in coastline coordinates are <EAST> or <WEST>.

The coordinates in the coastline file must be grouped by coastline segments. Each segment must start with a two field header record, of which the first field is an integer designating the number of coordinate pairs in that segment, and the second field is a character string identifying the segment. The coordinates must be paired in successive records, with latitude in the first field and longitude in the second field of each record.

<QUIT>

This keyword must be entered as the last line in the command file.

The following is an example of a command file for MAKOVRLA.

```
CSTFIL.DAT  (name of overlay plot file)
OVERLAY FOR LOS ANGELES BIGHT  (title)
122W 32N 117W 35N 1.0 1.0 1 160 99 2  (header fields)
COAST EAST COASTLINE.DAT  (east longitudes are neg.)
```

```
SYMBOL 13 0.16 0 120.5W 34.5N
PT CONCEPTION (strings start on col 1)
SYMBOL 9 0.16 0 118.3W 33.7N
SAN PEDRO
SYMBOL 9 0.16 0 117.2W 33.2N
SAN DIEGO
SCALES 7 0.167 0.75 118.5W 34.5N
NUMBER 4 0.12 0
118.5W 35.3N 0 0
118.167W 35.3N 20 0
117.833W 35.3N 40 0
117.5W 35.3N 60 0
SYMBOL 14 0.12 0 118.5W 34.0N
nautical miles
QUIT
```

In the VAX 11-780 implementation, the command file is an executable file and, for this example, would need the VAX DCL command <$RUN MAKOVRLA> inserted at the beginning and the command <$EXIT> added at the end. In the PC compatible implementation, <MAKOVRLA> is executed as a DOS command and the program reads the command file as a data file.

In either case, the example would create an overlay plot file with the following features:

1. California coastline from 32N to 35N and the channel islands (from a file named COASTLINE.DAT).
2. The names PT CONCEPTION, SAN PEDRO and SAN DIEGO, at those locations.
3. A scale of nautical miles from 0 to 60 in the upper right corner of the plot, with tic marks at intervals of 10, labels at every other tic mark, and the string <nautical miles> below it.

Figure 1 of this document was made with MAKOVRLA.

FITTING RANDOMLY DISTRIBUTED DATA TO A GRIDFIELD

The purpose of analyzing randomly distributed source data to a rectangular grid is for convenience in tracking contours for graphical representation of the data field, and for combining or comparing different sets of data. The resulting gridfield is explicitly defined only at the grid points and any information which the source data may have contained, detailing features between grid points, is not retained. In addition, the process of fitting data values to grid points introduces a measure of spatial distortion. These factors should be considered in selecting the mesh lengths (<XGD>, <YGD>) for a gridfield. The mesh lengths should be compatible with the spatial distribution of the data values. If the gridfield is too coarse, it cannot retain the full resolution afforded by the data field. If it is too fine, superfluous processing is required to perform the analysis.

In EDMAP, the source data values are assigned directly to one or more grid points within one mesh length of the respective data points. Grid points which are not assigned values directly, become target points of an interpolation procedure. Each of these procedures is described below.

1. Direct assignment of data values to grid points.

Each data value contributes to the definition of the gridfield at one or more grid points in its immediate proximity. If the qualifier option, <CENTER>, is submitted with <ANALYZE>, the I and J coordinates for each data value will be rounded to the nearest integer, effectively assigning the data values to the nearest respective grid points. Otherwise, (if <PJC><>4) a weight, W(i), will be computed for the grid point at each corner (i) of the grid square containing each data point, using the following formula:

$$W(i)=(1-delI(i)^2+delJ(i)^2)/SUM(1-delI(i)^2+delJ(i)^2),\ i=1..4$$

where delI and delJ are the incremental distances from the data point to the grid points, <^> denotes exponentiation and SUM designates summation for i=1..4. This formula gives each data value a total weight of 1.0, whether it contributes to one, two, three or four grid point values. The data value is multiplied by the weight for each of the adjacent grid points and the products are accumulated for each grid point, along with the associated weights, until all of the data values have been processed. If the accumulated weights for a grid point reaches 100, no additional contributions from data values are accepted for that point. When the assignment of data to the gridfield is completed, a value for each grid point affected is computed by

dividing the accumulated products for that point by the sum of the accumulated weights.

A different procedure is used for the special case where <PJC>=4, which designates a gridfield as an oceanographic section, for which the Y coordinate is depth. Data values in the source file are expected to be ordered by depth (from the surface downward) at discrete locations along the X coordinate, for example, at oceanographic stations. In the analysis process, linear interpolation to horizontal grid lines will be performed using the vertically distributed values at each such location (or station) along the X coordinate. Horizontal interpolation will then performed to determine values at vertical grid lines.

When all of the data values have been processed, the second phase of analysis will be initiated, unless the value of <ANL> is equal to 1, which would cause an exit from the analysis routine. This option provides an opportunity to print or save the gridfield in a grid file before interpolated values are added. The saved grid file can be retrieved in a subsequent run to continue the analysis.

2. Interpolation to grid points not directly defined by data.

In this phase of the analysis process, the gridfield is scanned twice in an attempt to interpolate values for target grid points, which remained undefined after phase 1. In the first scan, only those grid points which were assigned values in phase 1 are used for interpolation. This renders the results independent of the starting point and direction of the scan. In the second scan, the values added in the first scan are used also.

The size of the search area, around each target point, will be determined by the value of <ANL>. If this parameter is submitted as a mixed number, the integer part will be used to set the horizontal search range, ANLH, and the fractional part (multiplied by 10) will be used to set the vertical search range, ANLV. If <ANL> is an integer, its value will be assigned to both ANLH and ANLV. For a target grid point at coordinates (I,J) and a reference grid point (with value assigned) at coordinates (I+L,J+K), the boundaries of the search area are defined as:

I(+or-)(ANLH-1), J(+or-)(ANLV-1)

with the restriction that (L*L+K*K) must be less than or equal to the larger of:

(ANLH-1)^2+4 or (ANLV-1)^2+4

where <^> denotes exponentiation. The effect of the restriction is to cut off the corners of the rectangular search area when ANLH and ANLV are large.

The search is conducted by selecting up to 12 reference grid point values in the search area. Selected grid point values will include those on either side of, and closest to, the target grid point on both the horizontal and vertical grid lines that pass through the target grid point. They also include the closest reference grid point value in the upper left, upper right, lower left and lower right sectors of the search area. If the two closest grid points in any sector are equidistant from the target grid point, both will be selected.

The selected values are used to compute intercepts on the horizontal and vertical grid lines passing through the target grid point. An intercept can be determined by a grid point value on one of these grid lines, or by linear interpolation between grid point values in adjacent corner sectors. Each intercept is assigned a weight, based on the sum of the squared distances of the associated grid points to the target grid point, and a category: Pos_K, Neg_K, Pos_L or Neg_L. The intercept with the lowest weight is chosen from each category for the final interpolations, provided that the associated grid points satisfy the range criteria. The latter are applied to the sum of the distances of the two grid points (used to compute the intercept) to the grid line on which the intercept is located. This sum must be less than or equal to ANLH for an intercept on the vertical line, or to ANLV for an intercept on the horizontal grid line.

Finally, two interpolations are made for the target grid point, using the (Pos_K,Neg_K) pair for one and the (Pos_L,Neg_L) pair for the other. Both intercepts in each pair must meet the range criteria, described above, to produce a valid interpolation. Each valid interpolation yields a value for the target grid point. If both values are obtained, a weighted average is computed from the weights associated with the respective intercepts.

In essence, this process attempts to find values for undefined grid points with a linear interpolation technique, using reference values at nearby grid points. The parameter <ANL> allows the user to specify the scope of "nearby". It does not extrapolate into areas for which no data exists, and will not introduce local maxima or minima at target grid points.

TRACKING CONTOURS THROUGH A GRIDFIELD

One of the reasons for fitting data from a scalar field to a rectangular grid is that it facilitates the computation of contours, which can be plotted or displayed as a graphical representation of the field. The procedure used in EDMAP to compute contours employs a search strategy which entails a systematic scan of the gridfield, to intercept specified contours and track them to their endpoints.

The gridfield scan begins at the grid origin, where (I,J)=(1,1), and proceeds around the grid perimeter in a counterclockwise sense. The scan is controlled by two program parameters: T, the perimeter level indicator and P, the orientation of the scan vector. The scan vector spans one pair of grid points on the current scan line. The values of T and P determine the starting point and the direction of scan lines, which extend across the gridfield, horizontally or vertically. The orientation of the scan vector is downward when P=0, to the right when P=1, upward when P=2 and to the left when P=3. The perimeter level indicator, T, is initialized with the value 1 for the outermost perimeter (the external boundary) of the grid. It is incremented by 1 each time the current scan line shifts inward, toward the center of the grid. The scan vector starts at the grid origin and progresses along the current scan line between successive pairs of grid points. At each position, the grid point values at the tip and base of the scan vector are tested to determine whether a contour has been intercepted. If so, the gridfield scan is temporarily interrupted and the tracking routine is initiated. Otherwise, the scan vector advances to the next position along the scan line.

To initiate tracking, the coordinates of the contour intercept, on the scan line, are stored and marked as the initial point of contour segment. The contour is then tracked into the grid square on the left side of the scan vector. The selected grid square is expanded and divided into subsquares, according to the value of the parameter <SQD>. In the expanded square, the values of the field at subsquare corners are computed with an interpolation formula derived from the equation of a third order polynomial and McLauren's series:

```
P(i)=P2+i*(P3-P2)+i*(i-1)*(P1-P2+P4-P3)/4+
     I*(i-1)*(i-0.5)*(P4-3*P3+3*P2-P1)/7.5
```

where P1,P2,P3,P4 are the values of four successive grid points along a horizontal or vertical grid line, and P(i) is the interpolated value at a subsquare corner at the incremental distance, i, between the second and third of the four grid points. If either of the outside values (P1 or P4) is undefined (equal to <NUL>) and the qualifier option, <FIXBDL>, was

submitted with <TRACKCNTRS>, the interpolation becomes linear. Four vertical interpolations followed by <SQD>-1 horizontal interpolations are required to compute values for all subsquare corners in the expanded grid square. The use of curvilinear interpolation for subsquare points produces smoother contours.

The main program parameters involved in the tracking routine are the grid indices (I1,J1), pointing to the expanded grid square defined above, the subsquare indices (I2,J2), pointing to the current subsquare through which the contour is being tracked, the subsquare scan vector orientation Q, which is initialized by P when an initial contour point is found, and the interpolated gridfield values at the base and tip of the subsquare scan vector. The latter spans two adjacent subsquare points. Each contour point is an intercept of the contour with a subsquare boundary and marks its entry into a new subsquare. With each such entry, the grid square and subsquare indices are adjusted as necessary and the scan vector is shifted from the side through which the new subsquare was entered, to each of the other sides, in turn, until the exit point of the contour from that subsquare is found. The process is straightforward, unless the exit point coincides with a subsquare corner. In that case, the tracking routine must determine which of three subsquares, sharing the exit corner point, the contour is entering. It accomplishes this by searching each of the three subsquares, in turn, for an exit.

When the configuration of the gridfield in a local area includes a hyperbolic, or saddle point, the contour may be tracked into a grid square with more than one exit. When the tracking routine detects a multiple exit condition, it will attempt to track the contour straight through the hyperbolic point (which is a point of intersection of two contours with the same value). There can be cases of multiple exits, involving subsquare corner points, which the tracking routine cannot resolve, due to the proximity of external or internal boundaries (internal boundaries set off areas which contain undefined grid points). In such cases, the tracking routine may prematurely terminate the contour being tracked, or it may retrace part of another contour. In general, however, the routine will follow a contour to an end point, which may be an external or internal boundary or, if the contour closes on itself, its own initial point.

When an end point is reached, the tracking indices, I1,J1,I2,J2 and scan vector parameter Q, are reset so that the tracking of the current contour can be resumed from its initial point in the opposite direction (outward), and continues until the second end point of the contour is reached.

As the perimeter scan proceeds through the gridfield, shifting inward form level to level, the same contour may be

encountered many times. In order to insure that the same contour is not tracked and saved (as output in a plot file) as a consequence of each new encounter, a reference array is maintained which contains a record of contours already tracked. Each time a new initial point is found during the perimeter scan, it is checked against those in the reference array before tracking is initiated. Each time the perimeter scan shifts (inward) to a new level, the reference array is purged of all entries representing points outside of the new perimeter. In this way, its size is kept at a minimum to reduce search time and memory requirements.

The contour coordinates computed by the tracking routine are accumulated in segments and stored in a disk file equated to the internal file identifier <PLTFIL>. This file is accessed in EDMAP by <PLOTCNTRS>, which inserts labels in the contour segments and converts the coordinates of the contour points to inches.

APPENDIX A. Summary of option and specification parameters

Run time parameters read by EDMAP from the user's command file, or set by default, are stored in arrays. The parameters are listed below by array index number, with a brief description of each.

Option parameters.

1 ADDFLD Adds a gridfield, saved on disk in a previous run, to the gridfield in memory.

2 ANALYZE Fits source data, converted to (I,J) coordinates by FETCHDAT, to a rectangular grid.

3 CENTER Qualifier option for ANALYZE; causes data values to be assigned to the nearest grid point.

4 CONCATPLT Concatenates plot features from two or more plot files onto one plot.

5 DIGITPLT Causes gridpoint values to be plotted as numbers at grid point locations.

6 EDITFLD Modifies a gridfield at run time by invoking the special procedure ADJUSTFLD.

7 FIXDBL Qualifier option for TRACKCNTRS; constrains the interpolation procedure used to track contours.

8 GUESSFLD Qualifier option for ANALYZE; provides a reference gridfield to screen source data values during analysis.

9-12 LOADF1, LOADF2, LOADF3, LOADF4 Causes a gridfield, saved on disk in a previous run, to be loaded into memory.

13 LOADSORC Loads source data from user's file and converts (X,Y) coordinates to (I,J) grid coordinates.

14 MOREDATA Qualifier option for LOADSORC; causes data to be loaded from a another source file before proceeding with analysis.

15 OVERLAYPLT Causes special plot features stored in an overlay plot file to be added to a plot.

16 PLOTCNTRS Produces a contour plot.

17 PRINTFLD Creates a printer file of the gridfield in memory, complete with row and column labels.

18-21 SAVEF1, SAVEF2, SAVEF3, SAVEF4 Causes the gridfield in memory to be saved in a disk file.

22 SETNUL Qualifier option for ANALYZE; causes the null value NUL, to be assigned to grid points not affected in the fitting of source data.

23 SKIPFIT Bypasses the fitting of source data to grid points during analysis.

24 SMOOTH Modifies the gridfield in memory with a 25 point two dimensional smoother.

25 SUBTRACT Subtracts a gridfield, saved on disk in a previous run, from the gridfield in memory.

26 TIMEPLOT Provides alternative labeling options for the X axis when the X coordinate is month.

27 TRACKCNTRS Tracks selected contours through the grid-field in memory and saves the coordinates in a plot file.

28 VECTORPLT Plots wind data fitted to a gridfield, as arrows (direction) and numbers (speed) at grid points.

29 XYDATAPLT Plots data values, or symbols, at the actual locations of the data points.

30 IJVOPN Qualifier option for MOREDATA; automatically invoked to control accumulation of additional source data.

31 SETCNT Qualifier option for TRACKCNTRS; provides alternate mode of contour selection.

32-35 DATPLT, CTRPLT, GRDPLT, VECPLT Qualifier options for CONCATPLT; designates plot file type for concatenation.

36 RECTIFY Provides a way to rectify common boundaries of gridfields which are to be plotted on the same plot with CONCATPLT.

Specification parameters

1-2 IMX, JMX Dimensions of the gridfield, computed automatically and used to control operations on the grid.

3-4 XZO, YZO (X,Y) coordinates of the lower, left corner of the gridfield.

5-6 XMX, YMX (X,Y) coordinates of the upper, right corner of the gridfield.

7-8 XGD, YGD Specifies grid increment, or mesh length, for the X and Y coordinates, respectively.

9 PJC Code value from 1 to 5 specifying type of coordinates.

10 MPR Reference longitude for converting the X coordinate values when PJC is 1,2 or 3.

11 NUL Specifies a value to be assigned to undefined grid points when SETNUL is true.

12 SCL Used as a power of 10 to scale data values when defining the gridfield. Preserves significance for decimal fractions.

13 SYM Code value designating data value or symbol to be plotted when XYDATAPLT is true.

14 SQD Subsquare division factor specifying resolution of points computed when tracking contours through a grid square.

15 LRL Logical record length determined automatically to block records when creating grid files.

16 SMH Code value to select smoothing operator when SMOOTH is true.

17 GSS Constant grid point value used to initialize a gridfield as a reference field for editing data values when ANALYZE and GUESSFLD are true.

18 ANL Code value specifying scope of interpolation when computing values for undefined grid points.

19 REJ Specifies a range, relative to a reference field, for accepting, or rejecting, data values when ANALYZE and GUESSFLD are true.

20 CIN Specifies a contour interval for contour selection when TRACKCNTRS is true.

21 COG Specifies a contour origin to be used with CIN for selecting contours. It also sets the minimum contour value.

22 CTL Code value used to control labeling of contours when PLOTCNTRS is true.

23-24 MFX, MFY Determine the lengths of the X and Y axes, respectively.

25 HGT Specifies the height of the plot title and of axis and contour labels.

26-27 XTC, YTC Specify how tick marks will be plotted along the X and Y axes, respectively.

28-29 XLB, YLB Specify how labels will be plotted be plotted along the X and Y axes, respectively.

30-32 ROT, XPV, YPV Specify an angle for plot rotation and X and Y coordinates of the pivot point.

33 SPB Code value to permit or suppress plotting of the plot border.

34 ORG Specifies an upward displacement of the plot origin, where (I,J)=(0,0).

35 CTX Specifies a base for selection of contour intervals exponentially.

36 VEC Controls the length of arrows and plotting of magnitudes on vector (wind) plots.

37-38 XLP, YLP Specify starting points for plotting labels along the X and Y axes, respectively.

39-40 XLD, YLD Specify the number of decimal places to be plotted in labels along the X and Y axes, respectively.

41 DPL Specifies the number of decimal places to be plotted in data or grid values when XYDATAPLT or DIGITPLT is true.

APPENDIX B. Plot parameters for CALLPSUB

CALLPSUB is a small procedure in an external program module that addresses specific plotter software. In the implementation of EDMAP for the VAX 11-780, CALLPSUB constructs plot calls for subroutines in the ZETA plot package. In the IBM PC implementation, CALLPSUB creates an ASCII file of plot calls for input to programs written to drive specific plotters. Two such programs, written in GWBASIC, are available: TEKDRIVR.BAS for the Tektronix 4662 plotter, and HPDRIVR.BAS for the Hewlett Packard 7470A plotter.

The parameters passed to CALLPSUB are used to construct plot calls for five basic plot functions: ORIGIN, PLOT, SYMBOL, NUMBER and LINE. The parameters for the VAX and PC versions of CALLPSUB are identical, with one exception. A file parameter, TEKFIL, was added to the PC version (for the ASCII output file) to prevent it from being closed with every exit from CALLPSUB. Each parameter is described below.

TEKFIL ASCII output file parameter created by CALLPSUB (PC version only).

PNAM Plot call type with one of five values: <ORIG>, <PLOT>, <SYMB>, <NUMB> or <LINE>.

X,Y Type real (floating point) arrays with index range 1..240, containing plot coordinates in inches. The first element in each array, X[1],Y[1], are move coordinates for all plot call types. The remaining elements are used only with <LINE>.

PN Type integer array with index range 1..240. The contents provide pen control for <PLOT> and <LINE> type plot calls. The first element, PN[1], specifies length of string for <SYMB> and number of decimal places for <NUMB>.

HT Specifies height of character for <SYMB> or <NUMB>. It is not used with other plot types.

NUM The number to be plotted with plot type <NUMB>, or a symbol code with <SYMB>.

STR The string to be plotted with <SYMB>. The length of the string is contained in PN[1].

THETA Specifies a rotation for plotting strings or numbers, in degrees (positive counterclockwise). The pivot point for rotation is the lower left corner

of the first character in the string or number. The coordinates of this point are given by X[1],Y[1].

In the PC version of CALLPSUB, the parameters received are used to construct statements containing a plot type identifier and the numeric or string constants needed for each call. As noted above, a CALLPSUB parameter may be interpreted differently for different plot call types. These statmemts are written to TEKFIL. The format for each type is described below.

PLOT X[1] Y[1] PN[1]

PN[1]=0 means initialize plotter.
PN[1]=2 means draw to X[1],Y[1].
PN[1]=3 means move to X[1],Y[1], pen up.

ORIG X[1] Y[1] PN[1]

X[1]=right offset of X origin.
Y[1]=upward offset of Y origin.
PN[1] is not currently used.

SYMB X[1] Y[1] PN[1] HT THETA STR

X[1],Y[1] are coordinates of the lower, left corner of the first character in STR or, if PN[1]=0, of an ASCII character whose code number is given by THETA.
PN[1] is the number of characters in the string to be plotted.
HT specifies the height of the characters, in inches.
THETA specifies the rotation of the string in degrees, except when PN[1]=0. In that case, it specifies an ASCII character code.
STR is the string to be plotted.

NUMB X[1] Y[1] PN[1] HT THETA NUM

X[1],Y[1] are coordinates of the lower, left corner of the first digit in NUM.
PN[1] specifies the number of decimal places to be plotted in the number. If PN[1]=0 the decimal point will be supressed.
HT specifies the height of the digits, in inches.
THETA specifies the rotation of the number, in degrees.
NUM is the number to be plotted.

```
LINE PTS X1 Y1 X2 Y2 X3 Y3...
```

PTS is the number of points in a contour or line segment, whose coordinates are contained in the array parameters X and Y. When CALLPSUB is entered with LINE, the parameters HT and NUM represent F and T, respectively. CALLPSUB computes PTS=T-F+1.

X1 Y1 X2 Y2 X3 Y3...are the point coordinates from X[F],Y[F] to X[T],Y[T].

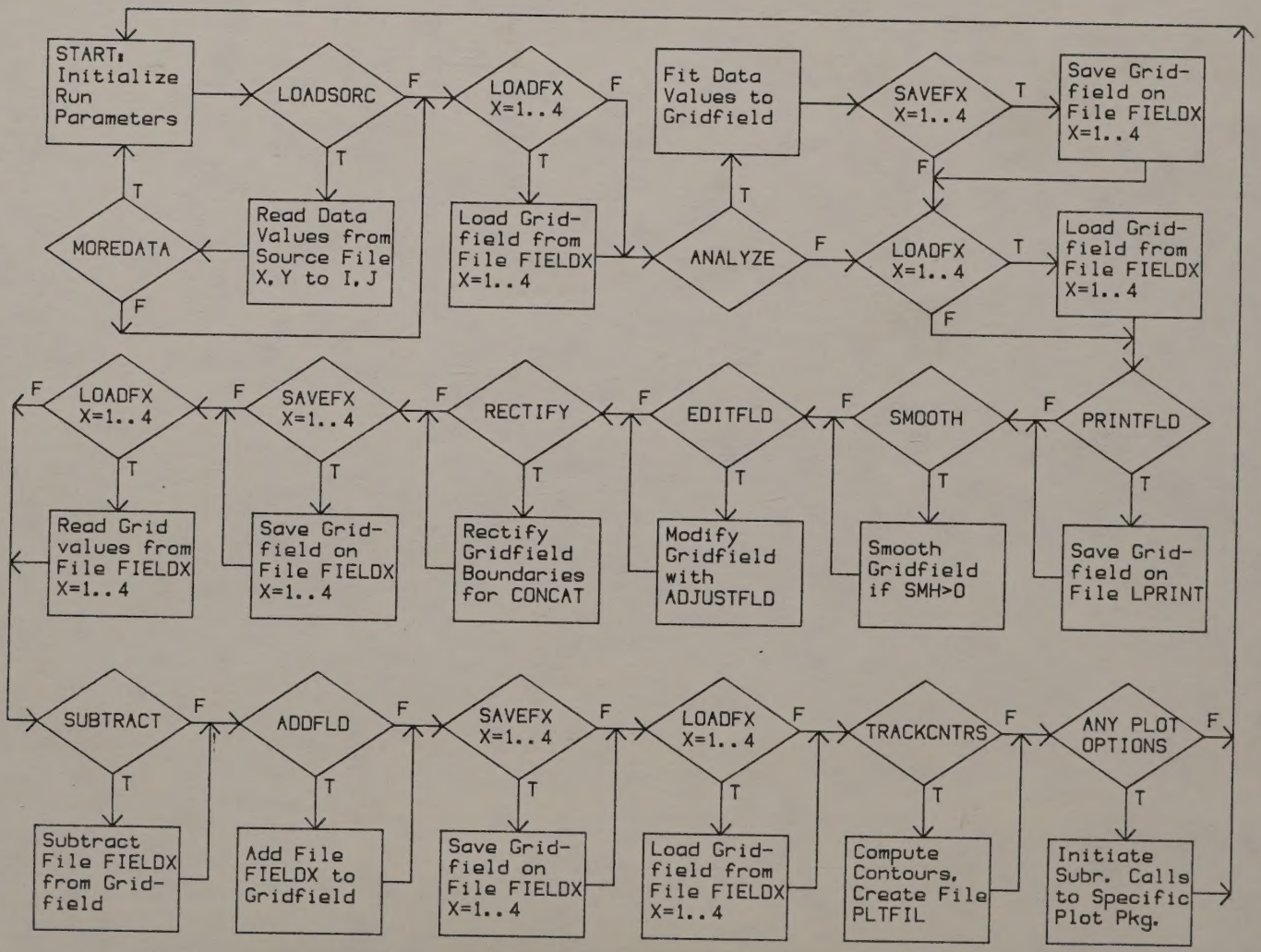

Figure 1. EDMAP FLOWCHART